

WHAT IS CLAIMED

1) Apparatus for the osteosynthesis of bone fractures by means of locked endomedullary nailing, of the type comprising:

- a tubular nail defining an internal coaxial through channel, provided with transverse through holes whose axis intersects the axis of the nail and able to be inserted in a medullar channel of a bone;
- a device for locating the axis of a predetermined hole selected among said holes, along which the bone is to be drilled to drive a corresponding screw for locking the nail on the bone;

wherein the locating device comprises:

- a source of electromagnetic power;
- an emitter of the electromagnetic power in the form of non ionising electromagnetic radiation, able to be inserted inside the nail along the internal channel from a proximal end of the nail at least to a working position, located on the axis of the predetermined hole, in which at least part of the non ionising electromagnetic radiation is directed from the emitter, through the predetermined hole, on an inner superficial portion of the cortex of the bone corresponding to the axis of the predetermined hole and generates, beyond an outer superficial portion of the cortex of the bone, also corresponding to the axis of the predetermined hole, a signal detectable from the exterior having an intensity distribution with its centroid in correspondence with the axis of the predetermined hole;
- a line for transmitting the electromagnetic power from the source to the emitter.

2) Apparatus as claimed in claim 1, wherein the centroid of the intensity distribution of the signal detectable from the exterior coincides with an intensity peak.

3) Apparatus as claimed in claim 1, wherein the non ionising electromagnetic radiation

egressing from the emitter has its spectrum distributed on a predetermined interval of wavelengths selected in the range that goes from near ultraviolet to mid infrared, ends included, the signal being essentially determined by the radiation portion transmitted through the bone tissues.

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4) Apparatus as claimed in claim 3, wherein the electromagnetic radiation egressing from the emitter is visible light.

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5) Apparatus as claimed in claim 4, wherein the wavelengths belonging to the predetermined interval are comprised between 600 nanometres and 700 nanometres.

6) Apparatus as claimed in claim 3, wherein the wavelengths belonging to the predetermined interval are comprised in the infrared range.

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7) Apparatus as claimed in claim 3, wherein the emitter comprises an optical collimation system that collimates the electromagnetic radiation in a beam within a predetermined solid angle centred on the optical system, the solid angle being coaxial with the predetermined hole when the emitter is in the working position.

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8) Apparatus as claimed in claim 4 or 5, wherein the emitter comprises an optical collimation system that collimates the electromagnetic radiation in a beam within a predetermined solid angle centred on the optical system, the solid angle being coaxial with the predetermined hole when the emitter is in the working position.

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9) Apparatus as claimed in claim 3 or 7, wherein the source directly generates the non ionising electromagnetic radiation, the transmission line comprising a waveguide for carrying

the electromagnetic radiation to the emitter.

10) Apparatus as claimed in claim 7, wherein the source directly generates the non ionising electromagnetic radiation, wherein the transmission line comprises a waveguide for carrying the electromagnetic radiation to the emitter and wherein the optical system, coupled to the waveguide, comprises a collimating lens and a deflector that deflects the radiation coming from the waveguide in the solid angle.

11) Apparatus as claimed in claim 1, wherein the source comprises an electrical power generator, the emitter comprises a heating element and the transmission line comprises an electrical wire connecting the heating element to the electrical power generator, the heating element emitting, when excited by the electrical power, electromagnetic radiation at wavelengths in the thermal infrared region.

12) Apparatus as claimed in claim 1, wherein the source comprises a surgical power laser and the emitter comprises a focusing optical system coupled with the transmission line, which, when the emitter is in the working position, directs and focuses the laser beam on a part of bone tissue in correspondence with the axis of the predetermined hole, the signal being defined by the perforation of the bone tissue operated with the laser beam, the apparatus further comprising protecting screens, able to be positioned in removable fashion around the fractured part to protect the operator from the action of the laser beam.

13) Apparatus as claimed in claim 3, wherein a centroid of the intensity distribution of the signal detectable from the exterior coincides with an intensity peak and in that the apparatus further comprises a contrast enhancement device, which can be positioned on the axis of the predetermined hole externally to the bone and acts on the portion of radiation transmitted

through the bone tissues enhancing the contrast between the intensity peak and a peripheral part of the signal and improving the resolution in the identification of the position of the axis of the predetermined hole.

5 14) Apparatus as claimed in claim 13, wherein the contrast enhancement device comprises an attenuating filter for attenuating the intensity of the radiation.

15) Apparatus as claimed in claim 14, characterised in that the attenuating filter comprises an attenuating element of the type with “neutral density” in the visible range.

10 16) Apparatus as claimed in claim 14, wherein the attenuating filter comprises an attenuating element that attenuates the transmission radiation whose wavelength is less than 600 nm.

15 17) Apparatus as claimed in claim 16, wherein the transmission spectrum of the attenuating element has a maximum for wavelengths between 600 nm and 700 nm.

18) Apparatus as claimed in claim 14, wherein the attenuating filter has an adjustable attenuation factor.

20 19) Apparatus as claimed in claim 14, wherein from the emitter egresses electromagnetic radiation with a predetermined polarisation state and wherein the attenuating filter comprises a polariser element to attenuate the portion of radiation transmitted by the bone tissues not having the polarisation state of the radiation originally egressing from the emitter.

25 20) Apparatus as claimed in claim 1, which further comprises a detector of the signal and a

related image converter, able to be positioned externally to the bone for identifying the centroid of the intensity distribution of the signal and visualising its position.

21) Apparatus as claimed in claim 1, which further comprises automatic positioning means for automatically positioning the emitter at the height of the plane defined by the axis of the predetermined hole and by the axis of the nail, acting at least when the emitter, inserted in the internal channel, is in proximity to the working position.

22) Apparatus as claimed in claim 21, wherein the automatic positioning means comprise means for centring the emitter on the axis of the nail acting at least when the emitter, inserted in the internal channel, is in proximity to the working position.

23) Apparatus as claimed in claim 22, wherein the means for centring the emitter of the axis of the nail comprise at least a widening of the diameter of a sheath of the transmission line at least in proximity to the emitter.

24) Apparatus as claimed in claim 23 wherein the widening extends to enclose the emitter with an element transparent to the electromagnetic radiation egressing from the emitter itself at least in the direction of the predetermined hole.

25) Apparatus as claimed in claim 22, wherein the means for centring the emitter on the axis of the nail comprise, at least in proximity to the predetermined hole, a narrowing of the internal channel around the axis of the nail.

26) Apparatus as claimed in claim 22, wherein the means for centring the emitter on the axis of the nail comprise at least two straps oriented radially relative to the transmission line

and positioned along it in proximity to the emitter.

27) Apparatus as claimed in claim 21, which further comprises an arrest reference for arresting the insertion of the emitter in the internal channel when the emitter reaches a working position.

28) Apparatus as claimed in claim 22, which further comprises an arrest reference for arresting the insertion of the emitter in the internal channel when the emitter reaches a working position.

29) Apparatus as claimed in claim 27, wherein the arrest reference comprises elements for stopping the motion of the transmission line in the nail when the emitter reaches the working position, acting between the transmission line and the wall of the internal channel and able to be elastically disengaged.

30) Apparatus as claimed in claim 28, wherein the arrest reference comprises elements for stopping the motion of the transmission line in the nail when the emitter reaches the working position, acting between the transmission line and the wall of the internal channel and able to be elastically disengaged.

31) Apparatus as claimed in claim 27, wherein the arrest reference comprises an abutment element, able to abut the proximal end of the nail or an extension thereof and able to be positioned along the transmission line in a position of arrest of the insertion of the transmission line in the internal channel corresponding to the working position of the emitter.

32) Apparatus as claimed in claim 28, wherein the arrest reference comprises an abutment element, able to abut the proximal end of the nail or an extension thereof and able to be positioned along the transmission line in a position of arrest of the insertion of the transmission line in the internal channel corresponding to the working position of the emitter.

33) Apparatus as claimed in claim 31, wherein the terminal segment of the transmission line destined to be inserted in the internal channel is enclosed by a substantially rigid sheath and wherein the abutment element and the proximal end of the nail or its extension comprise mutual engagement means for the certain orientation of the emitter with an axis of emission thereof parallel to the axis of the predetermined hole.

34) Apparatus as claimed in claim 32, wherein the terminal segment of the transmission line destined to be inserted in the internal channel is enclosed by a substantially rigid sheath and wherein the abutment element and the proximal end of the nail or its extension comprise mutual engagement means for the certain orientation of the emitter with an axis of emission thereof parallel to the axis of the predetermined hole.

35) Apparatus as claimed in claim 21, which further comprises means for the certain orientation of the emitter with an axis of emission thereof parallel to the axis of the predetermined hole at least in proximity thereto.

36) Apparatus as claimed in claim 22, which further comprises means for the certain orientation of the emitter with an axis of emission thereof parallel to the axis of the predetermined hole at least in proximity thereto.

37) Apparatus as claimed in claim 27, which further comprises means for the certain orientation of the emitter with an axis of emission thereof parallel to the axis of the predetermined hole at least in proximity thereto.

5 38) Apparatus as claimed in claim 28, which further comprises means for the certain orientation of the emitter with an axis of emission thereof parallel to the axis of the predetermined hole at least in proximity thereto.

10 39) Apparatus as claimed in claim 35, wherein the means for the certain orientation of the emitter comprise means of mutual interference between the terminal segment of the transmission line, destined to the be inserted in the internal channel, and the wall of the internal channel, which determine the orientation of the emitter allowing the transmission line to slide in the internal channel.

15 40) Apparatus as claimed in claim 36, wherein the means for the certain orientation of the emitter comprise means of mutual interference between the terminal segment of the transmission line, destined to the be inserted in the internal channel, and the wall of the internal channel, which determine the orientation of the emitter allowing the transmission line to slide in the internal channel.

20 41) Apparatus as claimed in claim 37, wherein the means for the certain orientation of the emitter comprise means of mutual interference between the terminal segment of the transmission line, destined to the be inserted in the internal channel, and the wall of the internal channel, which determine the orientation of the emitter allowing the transmission
25 line to slide in the internal channel.

42) Apparatus as claimed in claim 38, wherein the means for the certain orientation of the emitter comprise means of mutual interference between the terminal segment of the transmission line, destined to be inserted in the internal channel, and the wall of the internal channel, which determine the orientation of the emitter allowing the transmission line to slide in the internal channel.

43) Apparatus as claimed in claim 39, wherein the means of mutual interference means comprise a fin positioned on the transmission line in proximity to the emitter and able to be inserted in sliding fashion at least with one of its ends in a corresponding guiding groove obtained on the surface of the internal channel.

44) Apparatus as claimed in claim 40, wherein the means of mutual interference means comprise a fin positioned on the transmission line in proximity to the emitter and able to be inserted in sliding fashion at least with one of its ends in a corresponding guiding groove obtained on the surface of the internal channel.

45) Apparatus as claimed in claim 41, wherein the means of mutual interference means comprise a fin positioned on the transmission line in proximity to the emitter and able to be inserted in sliding fashion at least with one of its ends in a corresponding guiding groove obtained on the surface of the internal channel.

46) Apparatus as claimed in claim 42, wherein the means of mutual interference means comprise a fin positioned on the transmission line in proximity to the emitter and able to be inserted in sliding fashion at least with one of its ends in a corresponding guiding groove obtained on the surface of the internal channel.

47) Apparatus as claimed in claim 21, wherein at least the terminal segment of the transmission line destined to be inserted in the internal channel comprises a support element with high torsion constant.

5 48) Apparatus as claimed in claim 22, wherein at least the terminal segment of the transmission line destined to be inserted in the internal channel comprises a support element with high torsion constant.

10 49) Apparatus as claimed in claim 27, wherein at least the terminal segment of the transmission line destined to be inserted in the internal channel comprises a support element with high torsion constant.

15 50) Apparatus as claimed in claim 28, wherein at least the terminal segment of the transmission line destined to be inserted in the internal channel comprises a support element with high torsion constant.

20 51) Apparatus as claimed in claim 35, wherein at least the terminal segment of the transmission line destined to be inserted in the internal channel comprises a support element with high torsion constant.

52) Apparatus as claimed in claim 36, wherein at least the terminal segment of the transmission line destined to be inserted in the internal channel comprises a support element with high torsion constant.

25 53) Apparatus as claimed in claim 37, wherein at least the terminal segment of the transmission line destined to be inserted in the internal channel comprises a support element

with high torsion constant.

54) Apparatus as claimed in claim 38, wherein at least the terminal segment of the transmission line destined to be inserted in the internal channel comprises a support element with high torsion constant.

55) Apparatus as claimed in claim 21, wherein at least the terminal segment of the transmission line destined to be inserted in the internal channel is enclosed by a substantially rigid sheath.

56) Apparatus as claimed in claim 22, wherein at least the terminal segment of the transmission line destined to be inserted in the internal channel is enclosed by a substantially rigid sheath.

57) Apparatus as claimed in claim 27, wherein at least the terminal segment of the transmission line destined to be inserted in the internal channel is enclosed by a substantially rigid sheath.

58) Apparatus as claimed in claim 28, wherein at least the terminal segment of the transmission line destined to be inserted in the internal channel is enclosed by a substantially rigid sheath.

59) Apparatus as claimed in claim 35, wherein at least the terminal segment of the transmission line destined to be inserted in the internal channel is enclosed by a substantially rigid sheath.

60) Apparatus as claimed in claim 36, wherein at least the terminal segment of the transmission line destined to be inserted in the internal channel is enclosed by a substantially rigid sheath.

5 61) Apparatus as claimed in claim 37, wherein at least the terminal segment of the transmission line destined to be inserted in the internal channel is enclosed by a substantially rigid sheath.

10 62) Apparatus as claimed in claim 38, wherein at least the terminal segment of the transmission line destined to be inserted in the internal channel is enclosed by a substantially rigid sheath.

15 63) Apparatus as claimed in claim 1, which further comprises a fastening pin for fastening a tubular hand piece to the nail, the fastening pin being tubular, coaxial to the nail and with its inner diameter corresponding to the diameter of the internal channel of the nail.

20 64) Apparatus as claimed in claim 1, wherein the nail comprises emitters, already appropriately positioned and aligned at least in front of corresponding distal holes, and corresponding segments of transmission line, also integrated in the nail and provided, at an opposite end relative to the emitters, with connectors to corresponding extensions of the transmission line through to the source.